Thermoelectricity at Solid/Liquid Interface of Colloidal Quantum Dot Arrays

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Nanostructuring is one of the most promising way to overcome the challenges to develop high performance thermoelectric materials.[1] One of the most important feature of colloidal quantum dots (QDs) in this respect is the formation of quasi-atomic discrete energy levels resulting from the quantum confinement effect. This feature lead to sharp density of states that beneficial for thermoelectric, if we are able to fill them. On the other hands, well-ordered tightly-bonded monolayers of solid assemblies of nanoscale QDs might be transparent for electrons to diffuse, but with large amount of boundaries for phonons to scatter. This would lead to the decoupling of electronic and thermal conductivity. While so far the most common approach to utilize colloidal QDs for thermoelectricity is limited as material sources for hot-pressed nanocomposite pellets and relies much on metal intercalation to enhance its electrical conductivity,[2] exploitation of the preserved quantum confinement effect has yet to be explored.

Through the interfacing between metal-chalcogenide colloidal QD arrays and ionic liquid, we demonstrate the measurement of high value of Seebeck coefficient reaching orders of mV/K at room temperature. The high Seebeck coefficient values stems from the interplay of field-induced doping by voltage-gated ionic liquid onto the QD arrays that enhance significantly the charge carrier density, so that the preserved discrete energy levels – quantum confinement effects – in the well-ordered arrays can be accessed.[3] Together with this, the large charge carrier density also enhance the electrical conductivity,[4] opens way for the demonstration of record-breaking thermopower value. Under scrutiny, it is not only the colloidal QD properties that contribute to the peculiar thermoelectric performance of this interface, but also the intrinsic electronic, thermal transport and rheology characteristics of the ionic liquids play some significant roles. This open new strategies to develop novel thermoelectric devices for micro-energy harvesting.

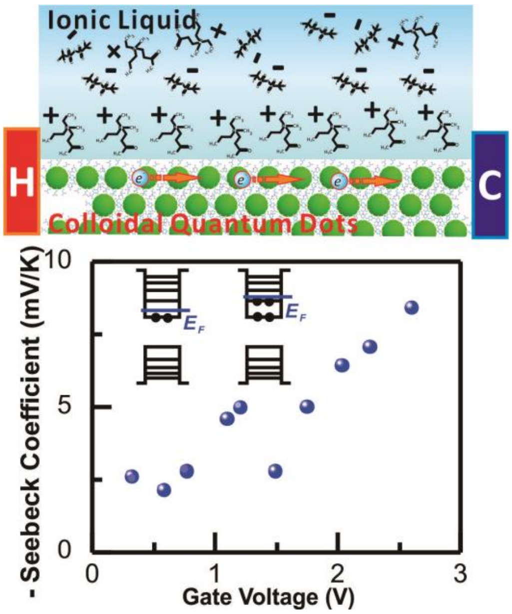

Figure 1 Schematic diagram of interface between colloidal QD array and ionic liquid from which gate-modulated Seebeck coefficient was observed.

Refs: [1] J. Urban, *Nature Nanotech.* 10, 997 (2015); [2] M. Ibanez, et al. *Nature Comm.* **7**, 10766 (2016); [3] S.Z. Bisri, et al. *Adv. Mater.* **26**, 5639 (2014); [4] S.Z. Bisri, et al. *Adv. Mater.* **25**, 4309 (2013).